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REVIEW: On the Relation Between Photographic Density, Light Intensity, and Exposure Time; by Frank E. Ross. *Jour. Optical Soc. Am.*, **4**, 255, 1920.* Photographic Sharpness and Resolving Power; by Frank E. Ross. *Astrophysical Jour.*, **52**, 201, 1920.*

The scope of these papers is very well indicated by their titles. The first represents an attempt by Dr. Ross to derive a reliable expression for the density recorded by a photographic plate, in terms of light intensity, length of exposure, and various parameters relating to maximum blackness and other qualities of the particular plate. The paper is introduced by a brief but critical review of previous attempts of a similar kind, after which the development of a new formula is undertaken. The derivation of the formula, like that of some of the others that have been suggested, is based on the principle of mass-action, but differs from the previous deduction in that it takes account of inequality in sensitiveness of different "grains" of silver salt in the film. Incident to this consideration there is involved the thickness of the emulsion, since absorption of light in the film reduces, in effect, the sensitivity of the deeply imbedded grains. The resulting expression affords a fairly satisfactory representation—better than that given by any of the previously suggested forms—of the observed density law, particularly in the case of an emulsion referred to as being of "type B", where the correspondence with the new formula is quite exact, and appeals to a reader admittedly unfamiliar with the technical side of photography as justifying in a very considerable degree the method of analysis which led to its formulation. Assuming the reasoning to be valid, the effect of such a matter as range of grain sensitivity, or thickness of the emulsion, can be recognized in its influence on the characteristics of the plate, and it is to be hoped that the investigation will prove suggestive of means to prepare plates having certain desired properties.

The paper concludes with an elegant derivation of the analytical relation which must hold in the formula for density, if we are to have simple time and intensity factors between any two given densities; that is to say, factors which are independent of the relative values of light intensity and exposure interval involved in the production of the record, and are dependent solely on the densities themselves. The foregoing rather involved statement refers to a really simple assumption which is frequently made in processes of photographic photometry, and the development of the analytical condition on which it depends has enabled the author to investigate some of the expressions that have been proposed to correlate intensity and exposure time. The "reciprocity law" and the Schwarzschild exponential formula are found to conform to the conditions, but the expression proposed by Kron violates one of them. In view of this inconsonance the author regards as desirable a more complete verification of that formula.

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*Contributions No. 93 and 90 from the Research Laboratory of the Eastman Kodak Company.

The first paper is of interest chiefly as a contribution to the study of technical photography while the second will appeal especially to astronomers, as sharpness and resolving power are most important considerations in the majority of cases in which photography is called to the observer's aid. In attempting a mathematical treatment of these subjects the author enters upon an almost untouched field. "Sharpness" which is defined as the derivative of photographic "density" with respect to distance measured at right angles to the edge of the image, is developed in terms of the "contrast" and "turbidity" factors (γ and κ). The expression for turbidity is derived with the assistance afforded by observations of photographic spreading, and the results are correlated with formulae used by astronomers to express the magnitudes of stars as functions of the diameters of their photographed images. The analysis is elegantly effected, and yields, as a by-product, a value of Schwarzschild's exponent "p" equal to unity; but while the method employed appears to be unexceptionable in its relation to a study of conditions beyond the border of an illuminated area, to which it is specifically applied, we are not fully convinced that the derived value of "p" could be adopted with perfect confidence in calculations of intensity within the border, which is the usual field of application of density formulae in their general use.

The formulae for sharpness are based and checked on the shadows of knife edges laid on the photographic film, and are thus free from effects attending the use of optical images. A set of shadows made with light of different wave-lengths, and reproduced as an illustration (Plate IX), is most illuminating with respect to the influence of wave-length on sharpness. It has been the experience of more than one spectroscopist that the best photographic definition obtainable in the lower part of the visible spectrum, and even in the blue, does not equal that which can be had in the violet, and the results here given show that the shortcoming is in photographic, rather than in optical imperfections, and in addition establish the specific causes of the phenomenon. The change of sharpness with increasing wave-length is explicable in terms of contrast and turbidity up to about $\lambda = 6000A$. Beyond that point agreement between observation and theory ceases, possibly, the author surmises, as the result of secondary photographic action. An interesting conclusion is that sharpness is independent of size of grain, a deduction which runs counter to the view that has heretofore generally been taken on the basis, apparently, of superficial considerations.

Resolving power is treated in a manner perhaps somewhat less precise than that adopted in relation to "sharpness", and is regarded as depending both on sharpness and size of grain. The effect on resolution of changes in the several factors which determine it is illustrated in a discussion of the properties of plates of different quality, and suggestions are offered touching the characteristics to be sought in plates designed for general astronomical photography, a subject on which the author can speak with the authority of an experienced observer. The subject is one of peculiar difficulty, and the paper makes no pretense to completeness of treatment, rather, "It has been the aim of the writer to show that resolving power can be put to a certain extent upon a mathematical basis, and that secondary effects can be explained in terms of four major factors, turbidity, contrast, size of grain, and graininess. It is clear that far from being the simple phenomenon imagined by Wadsworth, photographic resolving power draws upon the whole field of photographic theory and can be but imperfectly described even from the broadest viewpoint."

The papers are important, not only by reason of the accomplishments to which they relate, but also in the promise they hold for the further development of a mathematical treatment of photographic processes. That there is a need for such a development no one at all familiar with the scientific applications of photography will question. In the words of the author, the factors determining photographic action "are so numerous that it is impracticable even to specify them." But whatever the difficulties that beset the investigator in this field they are more than balanced by the desirability of as complete an exploration of it as is possible. In these days when the photographic plate is called upon to supplement the senses in the study of so many branches of natural science, we can hardly know too much of the nature of its reactions. Dr. Ross brings to bear on the intricacies of a difficult problem a rare equipment of experimental skill and analytical power, and both he and the Research Laboratory of the Eastman Kodak Company are to be felicitated upon accomplishments such as those represented in these papers.

A few typographical irregularities are noted, among which may be mentioned: *Journ. Opt. Soc. Am.*, **4**, p. 258, line 30, also p. 264, lines 13 and 21, insert κ; and *Astrophys. Journ.*, **52**, 209, bottom of page, for 2.5 read −.4.

W. H. W.

Ninety-Seventh Award of the Donohoe Comet Medal

The comet medal of the Astronomical Society of the Pacific has been awarded to Mr. J. F. Skjellerup, of Rosebank, Cape Town, South Africa, for the discovery of an unexpected comet on December 9, 1920.

W. W. Campbell,
S. Einarsson,
Committee.

NOTE

This comet is the one independently discovered by Mr. J. F. Skjellerup on December 13, 1920. The announcement of Mr. Skjellerup's discovery was the first to reach observers in the northern hemisphere. The 96th award of the Donohoe Comet Medal was made to him for his discovery. Later advices from South Africa show that Mr. Taylor had found the comet on December 9th and had promptly communicated his discovery to the Secretary and President of the Cape Astronomical Society. An unfortunate error of one hour in right ascension in reading his circles prevented the confirming of Mr. Taylor's discovery, and announcement of it to observers elsewhere. The comet should hereafter be known as Taylor-Skjellerup.